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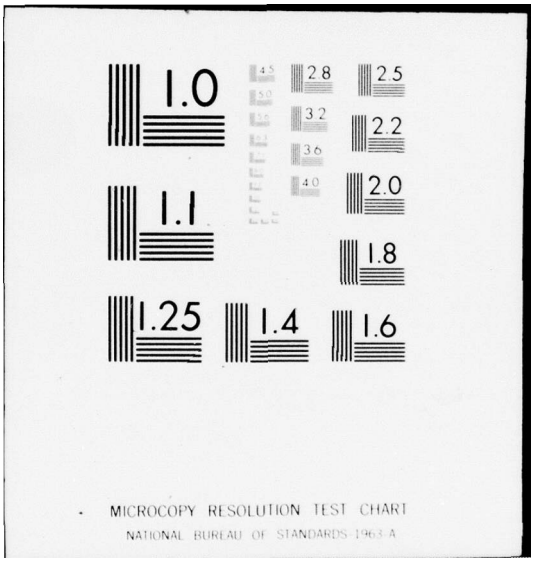
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Woods Hole Oceanographic Institution

A COMPLETE NAVIGATION AND TOTAL GEOMAGNETIC FIELD PROCESSING PACKAGE USING THE HEWLETT PACKARD 9830 CALCULATOR

by

Robert C. Groman
Hartley Hoskins

May 1977

TECHNICAL REPORT

Prepared for the Office of Naval Research under Contract N00014-74-C-0262; NR 083-004, and for IPOD Site Survey Management, Lamont-Doherty Geological Observatory, Columbia University under Contract CU-WHOI-25903, Amendment #1 (August 1976).

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A complete data processing package for navigation and total geomagnetic field anomaly is described for the Hewlett Packard 9830 calculator. These programs were designed, written and used during a two-week site survey funded through the International Program of Ocean Drilling (IPOD). These programs permit 1) entry of navigation and total field geomagnetics data; 2) data reduction of total field to magnetic anomaly; 3) data editing, and 4) data display in the form of annotated ship's track and profiled data along the ship's track.

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Approved for Distribution Elizabeth T. Bunce

Elizabeth T. Bunce, Acting Chairman
Department of Geology and Geophysics

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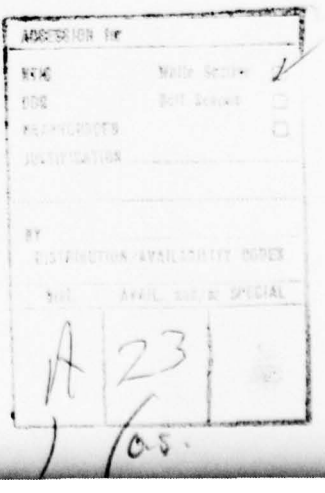


ABSTRACT

A complete data processing package for navigation and total geomagnetic field anomaly is described for the Hewlett Packard 9830 calculator. These programs were designed, written and used during a two-week site survey funded through the International Program of Ocean Drilling (IPOD). These programs permit 1) entry of navigation and total field geomagnetics data; 2) data reduction of total field to magnetic anomaly; 3) data editing, and 4) data display in the form of annotated ship's track and profiled data along the ship's track.

INTRODUCTION

A two week site survey funded through the International Program of Ocean Drilling (IPOD) took place from 1 to 15 September 1976 aboard the U.S.N.S. LYNCH (T-AGOR7). Two alternate sites isochronous to the Late Mesozoic site AT2.1 (formerly termed "2A") were surveyed. It is the purpose of this report to describe the data processing software written for the Hewlett-Packard 9830 calculator available on the LYNCH.

There was a need to chart the navigation, depths and magnetics data soon after collection, in order to make decisions on subsequent ship's tracks. The W.H.O.I. data acquisition system, general purpose computer and processing software were not available for this cruise. Although the underway data were digitized by hand and key-punched daily aboard ship onto computer cards for later processing at W.H.O.I., we needed an alternate processing package at sea.

These programs were written at sea during the first week of the cruise. They were written in BASIC and operated within the capabilities of the HP 9830. The software provided the following capabilities:

1. Navigation data logging, and calculation of speed and heading between fixes.
2. Even five minute geomagnetics position interpolation
3. Total magnetic regional field interpolation, measured magnetic field logging and anomaly calculation.
4. Edit routine for navigation data.
5. Edit routine for magnetic data.
6. Mercator charting with time annotated.
7. Mercator charting with magnetic anomaly plotted as a profile parallel to the ship's track.

Program write-ups and listings appear in Appendices 4 to 9 of this report.

EVOLUTION OF DATA PROCESSING SCHEME

At the start of the cruise the navigation data, consisting mostly of satellite fixes and dead reckoned positions, were hand plotted onto a large scale (16 inches per degree) predrawn Mercator base map. The depth data were transferred by hand to a similar map. Since the depths were digitized at about every five minutes, a program was written to calculate and list even five minute interpolated positions between the fixes. A separate program was written to calculate the speed and heading between fix pairs and was used to verify the positions. Another program was written to accept the interpolated five minute positions and the total measured geomagnetic field value. It calculated the regional field at each of the five minute values by linearly interpolating within the degree square, given the regional geomagnetic field at the time of the cruise for each corner of the degree square. A listing of time, position and anomaly were then made. Each step of the processing required a separate entry for the navigation information. These tasks were repetitious, tedious and unnecessary. We needed a simple but unified approach to the data collecting and display.

The Hewlett Packard 9830 calculator on the ship had limited input/output capabilities: one built-in cassette read/write unit. Merging of data between separate input devices was therefore not possible. However, the task of typing over 5000 numbers per day into the calculator was an incentive for improving the existing scheme.

The processing system that evolved uses the calculator memory to store approximately sixteen hours of navigation and magnetics data. The memory served as the random access storage device. Because of the calculator design, the data stored in COMMON was accessible to several programs having the same COMMON specification. The cassette unit provided storage for the data already processed and allowed for program overlaying.

Our initial goal was to eliminate the redundant task of keying in the navigation data three times. This was accomplished very quickly. Of course, once the data were collected and properly organized in memory, many other options became possible. In particular, since the calculator was connected to a flat bed plotter we were able to display the data on charts. The 10" x 15" plotter was quite small for the expanded (16"/degree) longitude Mercator scale used for mapping the area, and several charts were required to cover the survey area. These 'chartlets' were traced onto the base map. This was an improvement to the use of dividers and a Gerber for the 576 points of navigation and magnetics per day.

Three programs were used to make a "merged" data file consisting of data value, position and time of observation. The first program accepted the fixes, through the keyboard, and saved them in memory. After all the fixes were keyed in, the program produced a listing of speeds and headings between fixes. Missed fixes, mistaken data entries and bad dead reckoned positions could be identified in this way. An edit program was run to correct these errors. This editing routine allowed for modifying, inserting and deleting of fixes. After errors were removed, the third program was run. This program calculated even five minute positions between fixes. Two hundred of these times and positions could be stored in memory at a time. These data could then be stored on cassette for later use. The anomaly calculating program used this navigation data in calculating the regional field values.

PROGRAM LIMITATIONS AND RESTRICTIONS

There are several limitations in the programs due largely to the dispatch with which they were written. The site survey took place in the area bounded by 30 N, 20 N, 75 W and 65 W. Data entry verification was much simplified by taking advantage of this fact. Also, the cruise took place wholly within the month of September. Consequently, time interval calculations could be much simplified. The programs did not have to take leap years or changes in month into account.

Care was taken in the coding for error checking at data entry. Here too advantage was taken of the limited geographic scope of the survey. The regional magnetic field values based on the 1975.0 spherical harmonic coefficients have a positive gradient in the north-westerly direction. Whenever four regional field values were entered they were checked for this trend. These checks of the operator inputs repeatedly saved time.

These geographic restrictions will have to be revised in order to use this processing scheme at other survey sites. The ease of editing BASIC routines on the HP 9830 calculator makes such input checks readily implementable. The programs could be rewritten without these limitations. Whether a revision is justified depends on two factors: 1) the likelihood of a similar cruise with only the computing power of the HP 9830 available, and 2) the realization that the HP 9830 is not a general purpose, high speed computer. The first factor will certainly be met many times. Failure to appreciate the second factor could lead to unachievable expectations.

HP 9830 CAPABILITIES AND LIMITATIONS

The HP 9830 calculator as configured on the LYNCH had 7904 words of memory, a printer, a 10" x 15" flat-bed plotter and one cassette read/write unit. The calculator is programmable in the BASIC language with many additional features to allow communication with the cassette and operating system of the calculator.

The calculator keyboard is well designed. Keyboard entry and editing is easy and flexible. Programming in BASIC is simple and yet quite powerful. There is a great deal of flexibility in the use of the cassette for program and data storage. Indeed, it would not have been possible to write, debug and use so many programs in such a short time if the HP 9830 were not such an easy machine to use.

When our efforts resulted in our first, neatly drawn and useful chart, we were very pleased. However, once the novelty wore off and the task of data entry, editing and charting became routine, we noticed how slow the calculations and plotting actually were, compared to a general purpose minicomputer and graphic devices. The calculator does not have large amounts of semiconductor or mass storage memory. BASIC programs are not precompiled but rather recompiled each time they are run. The plotter provided an effective 9 inch by 13.5 inch plotting area inasmuch as a margin had to be left for annotations. We were able to draw a grid 30 minutes in latitude and 50 minutes in longitude at the latitude of our survey. This restriction forced us to make several passes through the data before we had a complete set of charts.

CONCLUSION

An underway data logging, processing and graphic display software package was written and made operational on an HP 9830 calculator in a short time. These programs permitted data entry and merging of navigation and magnetics information, editing and plotting capabilities. Suitably revised, these programs could be used on other geophysical cruises where only limited computing power is available. Clearly this software and the HP 9830 calculator cannot compete in speed or flexibility with a larger, general purpose minicomputer. But as a basic, portable, low maintainance hardware and software system it is a very attractive package.

APPENDIX I

Hewlett Packard 9830 Timing

A simple program was written to test how long certain computational operations took. The FOR...NEXT loop was used with various types and numbers of statements within the loop.

	# ITERATIONS	WITHIN LOOP	TIME (SECONDS)
1.	1000	no instruction	4.2
2.	1000	10 REM	12
3.	1000	1 K1=K1+1	12.5
4.	1000	10 K1=K1+1	82
5.	1000	1 K1=K1*1	14
6.	5000	1 K1=K1+1	60.5
7.	10000	1 K1=K1+1	122

Subtracting line 3 from line 4 above, yields:

1000*9 K1=K1+1 taking 69.5 seconds

Or, 0.008 seconds per add operation.

Because the programs are executed line by line, you pay a penalty for having non executing statements (like the REMARK) within your programs.

APPENDIX 2

ALLOCATION OF COMMON IN PROGRAM

The variables in common have the following meaning:

L - Array: stores information about available space for data and current number of data points defined.

- L(1) - maximum number of fixes that can be processed
- L(2) - maximum number of data points, at even five minutes, that can be processed
- L(3) - number of fixes actually in memory. The number of fixes logged plus those added by the edit routine minus those deleted
- L(4) - number of even five minute navigation points available in memory
- L(5) - number of defined magnetic anomaly points, (less than or equal to L(4))

Y - Array: string array, not used.

D - Array: the day number array, corresponding to each of the possible L(3) fixes in memory.

T - Array: the fix time array, hour, then minute stored separately.

N - Array: the fix latitude array, degrees, minutes.

W - Array: the fix longitude array, degrees, minutes.

P - Array: the five minute position array, latitude and longitude, in degrees and fraction.

A - Array: the time and data array.
First element: even five minute interpolated time.
Second element: magnetic anomaly value.
Third element: not used.

APPENDIX 3

PROGRAM LOADING FROM CASSETTE

With the correct program cassette loaded into memory it will be possible to:

1. Log navigation data into memory and produce a listing of fixes, speeds, headings and distances.
2. Edit (insert, delete, replace and list) navigation data.
3. Produce five minute interpolated positions and times from the navigation data.
4. Calculate the total magnetic regional field and the magnetic anomaly for each measured magnetic field value entered at corresponding five minute interpolated positions.
5. Edit (delete, replace and list) magnetic anomaly values.
6. Plot a Mercator chart annotated with time.
7. Plot a Mercator chart with the magnetic anomaly plotted in profile, parallel to the ship's track.

The directions below apply to cassette #3. This cassette contains programs 1-4 from above. These programs are stored as one file. REM (comment) statements have been removed to conserve calculator memory.

LOADING CASSETTE #3:

1. Place program cassette #3 into the cassette reader and close the door.
2. Type in

   LOAD KEY 0

3. Push the EXECUTE key. This procedure places the correct instructions into the function keys f1-f4.

APPENDIX 3 (continued)

4. The cassette unit will start reading and the display will blank out. When the cassette has stopped reading the '└' symbol will again appear in the display.
5. Type in

LOAD 1

6. Push the EXECUTE key.
7. When the symbol again appears in the display, indicating that the cassette unit has finished reading, rewind the program cassette by pushing the REWIND key. This key is located in the upper right hand corner of the keyboard.
8. After the cassette unit has stopped moving (look into the cassette unit through the window), remove the cassette from the read unit.

Four programs are now available. They are:

1. FIX DATA LOGGING (f1)

2. FIX EDIT (f2)

3. FIX INTERPOLATION (f3)

4. MAGNETICS DATA LOGGING AND ANOMALY CALCULATION (f4)

To select one of these programs push the correct function key located on the upper left hand part of the keyboard. The function keys are given in parentheses above. For example, to run the fix interpolation program push the function key labeled f3.

APPENDIX 4

NAVIGATION LOGGING AND FIX CHECKING

If the program is not in memory, then see the detailed instructions (Appendix 3) on how to load programs from the program cassette. Rewind the program cassette by pushing the 'REWIND' key on the upper right corner of the keyboard. Remove the cassette after it has been rewound.

This program provides the means to enter fixes onto cassette and to calculate the speed, heading and distance between fixes. In addition, the speed, heading and distance calculations can be done for data already stored on cassette or already stored in memory.

Press the 'f1' function key, located on the upper left hand corner of the keyboard to begin the program.

The program will display the following question:

ENTER FILE # FOR DATA RESTORE?

If the data already exists on cassette and you want a new listing of speeds and headings, merely enter the file number in which the data is stored. The program will read the data from the cassette into memory and produce a list of the fixes with the calculated speed, heading and distance between each position. The program will go to the end of job section.

If the data is already in memory or if you want to enter a new set of navigation points, type in a -1 in response to this question.

If you have typed in a -1 the program then asks:

NEW FIX DATA?

If you answer "NO", then the program will use the positions already in memory to generate the list of speed and headings. After the list the program will go to the end of job section.

APPENDIX 4 (continued)

To enter new fix information respond with a "YES" to the question. You then enter the day, hour, minute, latitude degrees, latitude minutes, longitude degrees, longitude minutes, followed by the END OF LINE or EXECUTE key. North latitude and west longitude are assumed by the program so that signs (+ or -) need not be included. For example, for a fix on the 7th at 1026Z, at 25°15.4'N, 72°37.85'W enter the following:

7, 10, 26, 25, 15.4, 72, 37.85 (END OF LINE)

After the last fix has been entered, enter

0, 0, 0, 0, 0, 0, 0 (END OF LINE)

The zero entry tells the program that there are no more fixes. A listing of the fixes with speed, heading and distance between each fix will be printed. After the listing has been produced, the program goes to the end of job section.

End of job section: In this section the program asks the following question:

ENTER FILE # FOR DATA SAVING:

If you would like to save these fixes on cassette, enter in the file number to which you would like the data to be written. If you do not want to save the data at this step enter a -1. Be sure the data cassette is ready to accept data before you enter the file number.

FIXED DATA LOGGING

```
10 COM L(5,10),Y$[3],DI[30],TI[30,2],NS[30,2],WS[30,2],PS[200,2],NI[200,3]
20 DIM A$[3]
30 REM
40 REM   PROGRAM FIX DATA LOGGING
50 REM   DATA STORAGE AND PROCESSING PACKAGE FOR R.V LYNCH SEPT. 1976
60 REM
70 REM  ACCEPTS FIXES FOR STORING INTO COMMON FOR LATTER USE.
80 REM
90 REM  CALCULATES SPEED, HEADING AND DISTANCE AND PRINTS RESULTS.
100 REM
110 REM  HP 9830 - 6 SEPTEMBER 1976 - R. GROMAN
120 REM
130 REM  REFERENCE: THE AMERICAN PRACTICAL NAVIGATOR, BONDITCH, 1962
140 REM
150 REM   INPUT DAY, HOUR, MINUTE, LATITUDE, AND LONGITUDE.
160 REM   POSITION IS ENTERED AS DEGREES AND MINUTES.
170 REM
180 REM
190 REM RESTRICTION: LATITUDE IS ASSUMED TO BE NORTH (POSITIVE) AND
200 REM AND LONGITUDE IS ASSUMED TO BE WEST (NEGATIVE).
210 REM POSITION MUST BE WITHIN THE IPOD SURVEY AREA, LYNCH SEPT. 76.
220 REM DATA ENTERED MUST BE WITHIN THE SAME MONTH.
230 REM
240 DISP "FIX DATA LOGGING"
250 WAIT 4000
260 DISP "ENTER FILE # FOR DATA RESTORE";
270 INPUT F1
280 IF F1=0 THEN 310
290 LOAD  DATA F1
300 GOTO 730
310 L[1]=30
320 L[2]=200
330 DISP "NEW FIX DATA";
340 INPUT Z$
350 IF Z$="YES" THEN 730
360 L[3]=0
370 L[4]=0
380 L[5]=0
390 L[6]=0
400 L[7]=0
410 L[8]=0
430 L[9]=0
430 L[10]=0
440 !CP
450 REM ENTER FIX DATA
460 REM
470 FOR I=1 TO (L[1]+1)
480 I=I-1
490 IF I=L[1] THEN 730
500 DISP "DA, HR, MN, LAT, , LONG.";
510 INPUT D[I],T[I,1],T[I,2],N[I,1],N[I,2],W[I,1],W[I,2]
520 IF D[I]=0 THEN 730
530 IF N[I,2] >= 60 OR W[I,2] >= 60 THEN 650
540 IF N[I,1] <= 10 OR W[I,1] >= 40 THEN 650
```

```
550 IF ABS(NE I1,1]) >= 80 OR ABS(NE I1,1]) <= 60 THEN 650
560 IF W[ I1 ]>31 OR D[ I1 ]<0 THEN 650
570 IF T[ I1,1 ] >= 24 OR T[ I1,1]<0 THEN 650
580 IF T[ I1,2 ] >= 60 OR T[ I1,2]<0 THEN 650
590 N[ I1,1]=-ABS(NE I1,1])
600 N[ I1,2]=-ABS(NE I1,2])
610 GOTO 680
620 REM
630 REM ERROR FOUND
640 REM
650 DISP "*********NG. REENTER FIX"
660 GOTO 500
670 REM
680 NEXT I1
690 REM
700 REM
710 REM ALL FIXES ARE IN.  READY PRINER FOR FIX LIST.
720 REM
730 DISP "*** READY THE PRINTER ***"
740 WAIT 5000
750 PRINT
760 PRINT
770 PRINT "DAY HOUR  LATITUDE      LONGITUDE  HEADING   SPEED ";
780 PRINT "     KM      NM"
790 PRINT
800 FOR I1=2 TO L[3]
810 T1=D[ I1 ]*1440+T[ I1,1 ]*60+T[ I1,2]
820 T1=T1-D[ I1-1 ]*1440-T[ (I1-1),1 ]*60-T[ (I1-1),2]
830 O1=NE (I1-1),1 ]+NE (I1-1),2 ]/60
840 O2=WE (I1-1),1 ]+WE (I1-1),2 ]/60
850 N1=NE I1,1 ]+NE I1,2 ]/60
860 N2=WE I1,1 ]+WE I1,2 ]/60
870 REM
880 REM CALCULATE ANGLE, C, C=ARCTAN(D1/M1),
890 REM WHERE D1 IS THE DIFFERENCE OF LONGITUDE IN MINUTES,
900 REM AND M1 IS THE MERIDIONAL DIFFERENCE; CALCULATE THE
910 REM HEADING, H.
920 REM
930 D1=ABS(N2-O2)*60
940 M1=ABS(FNM(N1)-FNM(O1))
950 C=PI/2
960 IF M1=0 THEN 980
970 C=ATN(D1/M1)
980 H=FNA(C)
990 REM
1000 REM CALCULATE DISTANCE, X IN NM, D2 IN KM.
1010 REM
1020 X1=ABS(N1-O1)*60
1030 X2=ABS(N2-O2)*60*(X1/M1)
1040 X=SQR(X1*X1+X2*X2)
1050 D2=X*1.852
1060 REM
1070 REM CALCULATE SPEED, S, IN KNOTS.
1080 REM
1090 S=X/(T1/60)
1100 Z1=D[ I1-1 ]
1110 Z2=T[ (I1-1),1 ]*100+T[ (I1-1),2 ]
1120 Z3=NE (I1-1),1 ]
1130 Z4=NE (I1-1),2 ]
1140 Z5=WE (I1-1),1 ]
1150 Z6=WE (I1-1),2 ]
1160 WRITE (15,1170)Z1,Z2,Z3,Z4,Z5,Z6,H,S,D2,X
```

```
1170 FORMAT F3.0,F5.0,1X,F3.0,F7.2,3X,F4.0,F7.2,3X,F4.0,4X,F5.1,F9.1,F8.1
1180 NEXT I1
1190 Z1=D[L[3]]
1200 Z2=T[L[3],1]+100*T[L[3],2]
1210 Z3=N[L[3],1]
1220 Z4=N[L[3],2]
1230 Z5=W[L[3],1]
1240 Z6=W[L[3],2]
1250 WRITE (15,1170)Z1,Z3,Z3,Z4,Z5,Z6
1260 PRINT
1270 PRINT
1280 DISP "ENTER FILE # FOR DATA SAVING";
1290 INPUT F1
1300 IF F1<0 THEN 1320
1310 STORE  DATA F1
1320 DISP "ENTER FILE # OF NEXT PROGRAM";
1330 INPUT F1
1340 PRINT
1350 PRINT
1360 PRINT
1370 PRINT
1380 IF F1<0 THEN 1400
1390 LOAD F1,10,10
1400 END
1410 REM
1420 DEF FNA(C)
1430 REM
1440 REM GIVEN THE ANGLE, FUNCTION CALCULATES
1450 REM REAL HEADING BASES ON THE LATITUDE AND LONGITUDE DIFFERENCES.
1460 REM THE ANGLE RETURNED IS BETWEEN 0 AND 360 DEGREES.
1470 REM CONVENTION: O1, O2 ARE  THE OLD LATITUDE AND LONGITUDE;
1480 REM N1, N2 ARE THE NEW LATITUDE AND LONGITUDE, IN DEGREES.
1490 REM
1500 REM C  IS ANGLE IN RADIANS, IN THE RANGE -PI/2 TO +PI/2
1510 REM
1520 C1=ABS(C*57.29577951)
1530 IF N1<O1 THEN 1640
1540 REM
1550 REM IN QUADRANTS I OR IV.
1560 REM
1570 IF N2<O2 THEN 1590
1580 RETURN C1
1590 C1=360-C1
1600 RETURN C1
1610 REM
1620 REM IN QUADRANTS II OR III.
1630 REM
1640 IF N2 <= O2 THEN 1700
1650 C1=180-C1
1660 RETURN C1
1670 REM
1680 REM IN QUADRANT III.
1690 REM
1700 C1=C1+180
1710 RETURN C1
1720 END
1730 REM
1740 DEF FNA(L1)
1750 REM
1760 REM CALCULATES MERIDIONAL PARTS FROM THE EQUATOR TO THE GIVEN LATITUDE
1770 REM IN DEGREES AND FRACTIONS OF DEGREE.
1780 REM
```

```
1730 REM REFERENCE: BOWDITCH, 1962.
1840 REM
1910 N9=(45+(L1/2))/57.29577951
1920 N9=7915.704468*LOG(TAN(N9))
1930 N9=N9-23.268932*SIN(L1/57.29577951)
1940 N9=N9-0.0525*((SIN(L1/57.29577951))^3)
1950 N9=N9-0.000213*((SIN(L1/57.29577951))^5)
1960 RETURN N9
1970 END
```

APPENDIX 5

FIVE MINUTE INTERPOLATED POSITIONS BETWEEN NAVIGATION FIXES

To start the program for interpolating positions between fixes, do the following:

1. Type RUN 4000
2. Push EXECUTE key

or, hit the F3 function key if the calculator has been "set up" (Appendix 3) for this option.

Turn on the printer in order to have a copy of your inputs and for the output.

The program has two options:

1. Returns an interpolated latitude and longitude (degrees and minutes) for any intermediate day, hour, and minute entered.

2. Lists interpolated positions at even five minute increments between fixes.

The second option is the one used for most navigation and data merging in this suite of programs.

Both options require entering the two positions in response to successive keyboard quiries.

To enter 4 September 0641 25°33.2'N 069°16.1'W,
type 4, 6, 41, 25, 33.2, 69, 16.1 (END OF LINE)

Similarly for the second quiry, to enter
4 September 1013 25° 38.1'N 068°57.4'W,
type 4, 10, 13, 25, 38.1, 68, 57.4 (END OF LINE)

The quiry "E DAY HR MIN OF OBSERVATION" will appear on the console. At this point three entries can be made.

1. For a specific time within the interval between the fixes, other than the time of the first fix, enter the day, hour and time.

APPENDIX 5 (continued)

For example, to enter 4 September 0919,
type 4, 9, 19 (END OF LINE)

The program will respond with the interpolated position and pause. To make another entry, hit the space bar and the quiry "E DAY HR MIN OF OBSERVATION" will be repeated.

2. For a listing of interpolated positions for each even five minute interval between fixes, enter the day, hour and minute of the first fix. In the example above, type 4, 6, 41. The program will respond with a listing and then repeat the quiry "E DAY HR MIN OF OBSERVATION".

3. At this point, if you wish to go on to the next navigation fix, enter 0, 0, 0 and the program will then move the second fix to the first and ask for a new second fix. If you wish, instead, to enter two other fixes, type STOP, EXECUTE, RUN4000, EXECUTE to restart the program.

NOTE:

The preceeding directions do not apply to the interpolating program used with the overall processing software package. This package allows for data to be saved in memory and on cassette for later use by other programs.

To use this program within the processing package, proceed as follows:

1. Start the program.

2. The program will request the cassette file number from which navigation data can be read back into memory. Type in the file number for the data file desired. If the data is already in memory, then enter a -1 (minus one).

3. The program will calculate even five minute interpolated times and positions between each fix. A listing of these will be made at the same time.

APPENDIX 5 (continued)

4. After all calculations, the program will request the file number on which you would like the data stored. Usually, this number will be the same as the input file number entered at step 2. If you do not want to save the data at this time, enter a -1 (minus one).

FIVE MINUTE INTERPOLATED POSITIONS

```
10 DIM L[3],Y$[3],D[30],T[30,2],N$[30,2],W$[30,2],P$[200,2],A[200,3]
20 REM
30 REM | CALCULATE 5 MINUTE POSITION OF OBSERVATION |
40 REM | BY LINEAR INTERPOLATION BETWEEN TWO FIXES |
50 REM
60 REM RESTRICTIONS: PROGRAM FIX DATA LOGGING MUST HAVE BEEN RUN FIRST.
70 REM ALL CONVENTIONS OF THIS PROCESSING PACKAGE MUST BE FOLLOWED.
80 REM
90 REM FOR THE HP 9830
100 REM  8 SEPT. 1976 - N. HOSKINS. MOD BY R. GROMAN.
110 REM
120 DISP "FIX INTERPOLATION FROM ARRAY"
130 I1=0
140 I2=0
150 WAIT 3000
160 DISP "ENTER FILE # FOR DATA RESTORE";
170 INPUT F1
180 PRINT
190 PRINT
200 PRINT
210 IF F1<0 THEN 230
220 LOAD  DATA F1
230 I1=(I1+1)
240 IF I1>L[3] THEN 1320
250 D0=D[I1]
260 H0=T[I1,1]
270 M0=T[I1,2]
280 L0=N[I1,1]
290 L1=N[I1,2]
300 L2=ABS(W[I1,1])
310 L3=ABS(W[I1,2])
320 REM CHECK IF VALUES REASONABLE
330 IF D0>31 OR D0<1 THEN 230
340 IF H0>23 OR H0<0 THEN 230
350 IF M0>59 OR M0<0 THEN 230
360 IF L0>30 OR L0<20 THEN 230
370 IF L1 >= 60 OR L1<0 THEN 230
380 IF L2 >= 75 OR L2<60 THEN 230
390 IF L3 >= 60 OR L3<0 THEN 230
400 REM D2,D3,D5 ARE MINUTES FROM START OF MONTH
410 D2=D0*1440+H0*60+M0
420 I1=I1+1
430 IF I1>L[3] THEN 1320
440 D1=D[I1]
450 H1=T[I1,1]
460 M1=T[I1,2]
470 L4=N[I1,1]
480 L5=N[I1,2]
490 L6=ABS(W[I1,1])
500 L7=ABS(W[I1,2])
510 REM CHECK IF VALUES ARE REASONABLE
520 IF D1>31 OR D1<1 THEN 420
530 IF H1>23 OR H1<0 THEN 420
540 IF M1>59 OR M1<0 THEN 420
550 IF L4>= 30 OR L4<20 THEN 420
560 IF L5 >= 60 OR L5<0 THEN 420
570 IF L6>=75 OR L6<60 THEN 420
580 IF L7 >= 60 OR L7<0 THEN 420
590 D3=D1*1440+H1*60+M1
600 REM IS MINUTES OF TIME BETWEEN FIXES
```

```
610 T0=D0-D2
620 L0=L0+L1/60
630 L2=L2+L3/60
640 L4=L4+L5/60
650 L6=L6+L7/60
660 REM M2 DEG OF LAT BETWEEN FIXES
670 M2=L4-L0
680 REM M3 DEG OF LONG BETWEEN FIXES
690 M3=L6-L2
700 REM INITIALIZATION COMPLETE
710 REM SET START TIME OF OUTPUT TO FIRST FIX.
720 D4=D0
730 H2=H0
740 M4=M0
750 IF D4=0 THEN 1210
760 M5=M4
770 H3=H2
780 REM  INTERPOLATE EVERY FIVE MINUTES
790 D5=D2
800 REM SET INTERPOLATED VALUES AT EVEN FIVE MINUTES
810 D7=5*INT(D5/5)
820 M5=M4+D7-D5
830 D5=D7
840 D5=D5+5
850 M5=M5+5
860 IF M5<60 THEN 950
870 M5=M5-60
880 H3=H3+1
890 IF H3<24 THEN 950
900 H3=H3-24
910 D4=D4+1
920 GOTO 950
930 D5=D4*1440+H2*60+M4
940 REM CHECK IF WITHIN INTERVAL OF TWO FIXES
950 IF D5<D2 THEN 1210
960 IF D5>D3 THEN 1210
970 REM MAKE INTERPOLATION
980 D6=(D5-D2)/T0
990 L8=M2*D6
1000 L9=M2*D6
1010 A0=L0+L8
1020 A1=L2+L9
1030 REM OUTPUT
1040 A2=INT(A0)
1050 A3=(A0-A2)*60
1060 A4=INT(A1)
1070 A5=(A1-A4)*60
1080 FIXED 0
1090 DISP (D5-720)/1440;H3*100+M5;
1100 STANDARD
1110 WRITE (15,1190)A2,A3,A4,A5
1120 I2=I2+1
1130 IF I2>L[2] THEN 1290
1140 L[4]=I2
1150 AL(I2,1)=H3*100+M5
1160 PI(I2,1)=A2+A3/60
1170 PI(I2,2)=-ABS(A4)-ABS(A5)/60
1180 GOTO 840
1190 FORMAT "LT",F3.0,F6.2,2X,"LG",F4.0,1X,F6.2
1200 REM SHIFT SECOND TO FIRST FOR CONSECUTIVE FIXES
1210 D0=D1
1220 H0=H1
```

```
1230 M1=N1
1240 L3=L4-L5/60
1250 L1=L5
1260 L2=L6-L7/60
1270 L3=L7
1280 GOTO 410
1290 DISP "DONE - NO MORE ROOM FOR DATA"
1300 WAIT 5000
1310 GOTO 1340
1320 DISP "DONE - NO MORE FIXES"
1330 WAIT 5000
1340 PRINT
1350 PRINT
1360 PRINT
1370 DISP "ENTER FILE# FOR DATA SAVING";
1380 INPUT F1
1390 IF F1<0 THEN 1410
1400 STORE  DATA F1
1410 DISP "ENTER FILE # OF NEXT PROGRAM";
1420 INPUT F1
1430 PRINT
1440 PRINT
1450 PRINT
1460 PRINT
1470 IF F1<0 THEN 1490
1480 LOAD F1,10,10
1490 END
```

APPENDIX 6

NAVIGATION EDIT

This routine allows you to edit the day, hour, minute, latitude and longitude of every fix stored in memory. New fixes can be inserted and old fixes can be deleted. The basis for editing any fix is its key number. This number corresponds to the fix's record number (or position) in storage. Since there can be up to thirty fixes in memory at one time, there are up to thirty keys. Key 7, for example, corresponds to fix 7. To help determine the key number of a particular fix, two commands are available. The L, or list, command produces a list of selected fixes from memory, along with their keys. The F, or find, command locates a particular fix and key number by day, hour and minute.

Initially the program requests that you enter the cassette file number containing the data to be edited. The prompt is:

```
ENTER FILE # FOR DATA RESTORE?
```

Type in the cassette file number where your data is located. If the data is already in memory, type in a -1 (minus one). If you have specified a valid file number, the cassette will be positioned and the data read into memory.

The program will next print:

```
# OF FIXES IN ARRAY = NN
# OF INTERPOLATED TIME POINTS IN ARRAY = MM
```

where values of NN and MM will depend on the data file chosen. NN should be between 1 and 30. MM should be between 0 and 200.

The program prompts for edit commands with the line:

```
EDIT OPTION (L,F,R,D,I,E)?
```

APPENDIX 6 (continued)

This line is referred to as the 'major options list'. The meaning and further input for each option is described below.

LIST (L)

The list option provides a means to list part or all of the navigation data, in sequential order, with corresponding key numbers for each fix. The LIST option prompts with:

LIST FROM-TO KEYS?

Type in the first and last, inclusive, keys that you want listed. If the first number specified is less than zero, then you will return to the major options list. If the second key number is larger than the number of fixes in memory, it will be redefined as the last fix. The first key number must be less than or equal to the second number.

FIND (F)

The find option allows you to determine the key number of any specific fix in memory. The find option prompts with:

FIND: DAY,HOUR,MINUTE?

Enter the day, hour and minute of the fix you are looking for. The program will print the key number for this fix if it is located. If it cannot find the fix it will display the message:

DATE NOT FOUND day time

where the 'day' and 'time' are the day and time searched for.

After printing the key number or displaying the above message you return to the major options list. If you enter a negative value for the day, the program returns immediately to the major options list.

APPENDIX 6 (continued)

REPLACE (R)

The replace option allows you to modify a fix already stored in memory. The replace option asks for the key number of the fix to be replaced:

REPLACE KEY #?

Enter the key number of the fix you want to modify. Entering a zero or negative number will cause the program to return to the major options list.

Once you have selected a key number, the program prompts you by displaying, in turn, the current value for day, hour, minute, latitude and longitude. As each current (or old) value is displayed, you enter in the new value. The program assumes west longitude so the sign of the longitude need not be entered. It will be made negative automatically. No check is made for valid data or backwards in times. Use the fix logging routine after editing any navigation data to check for correct positions and times.

DELETE (D)

The delete option allows you to delete an existing fix from memory. It prompts with:

DELETE KEY #?

Enter the key number to delete. A number less than or equal to zero will return you to the major options list. After the record is deleted the program prints:

KEY # n DELETED

and returns to the major options list. If 'n' is greater than the number of fixes in memory you will be asked to enter the key number again.

All records after the record deleted are renumbered. That is, if key number 3 is deleted, the record associated with key number 4 now is now number 3, etc.

APPENDIX 6 (continued)

INSERT (I)

The insert option allows you to add new navigation points to the data already stored in memory. The insert option prompts with:

INSERT DATA BEFORE KEY #?

Type in the key number of the record before which you want the new fix to be placed. Entering a 0 or negative number returns you to the major options list.

After typing in a valid key number the program prompts with:

INSERT DAY, HR, MIN, LAT, LONG?

Enter in the new fix day, hour, minute, latitude (degrees, minutes) and longitude (degrees, minutes). West longitude is assumed. This is the same form as used by the fix logging program. You need not enter the minus signs for west longitude. No check is made for valid positions. or times. Run the fix logging program to check speeds and headings after any edit to the navigation data.

All records after the newly added fix are renumbered with new keys. The new key is the old key plus one.

END (E)

When you are done editing, type in the "E" command to go to the end of job. The program will prompt with:

SAVE DATA BEFORE LOGGING!!!
ENTER FILE # FOR DATA SAVING?

Type in the cassette file number on which you want to save the edited data. If you do not want to save the data at this time, enter in a -1 (minus one).

```
10 COM L[10],Y$[3],D[30],T[30,2],NS[30,2],WS[30,2],PS[200,2],A[200,3]
20 DIM Z$[10]
30 REM
40 REM   EDIT ROUTINE FOR IPOD LYNCH PROCESSING PACKAGE.
50 REM
60 REM   7 SEPTEMBER 1976 - P. GRONAN
70 REM
80 REM RESTRICTIONS:  ALL CONVENTIONS FOR THE IPOD LYNCH PROCESSING
90 REM   PACKAGE MUST BE FOLLOWED.
100 REM
110 REM EDIT COMMANDS:
120 REM      E - END. (WILL REQUEST FILE NAME FOR DATA STORAGE)
130 REM      F - FIND. (NEEDS DAY, HOUR, MINUTE)
140 REM      R - REPLACE. (NEEDS KEY #)
150 REM      D - DELETE. (NEEDS KEY NUMBER)
160 REM      I - INSERT. (NEEDS KEY NUMBER. RECORD INSERTED BEFORE THIS #).
170 REM      L - LIST. (NEEDS START AND END KEY  NUMBERS).
180 REM
190 REM
200 DISP "EDIT ROUTINE"
210 WAIT 3000
220 DISP "ENTER FILE # FOR DATA RESTORE";
230 INPUT F1
240 IF F1<0 THEN 260
250 LOAD  DATA F1
260 PRINT
270 PRINT "   # OF FIXES IN ARRAY =";L[3]
280 PRINT "   # OF INTERPOLATED TIME POINTS IN ARRAY =";L[4]
290 PRINT
300 PRINT
310 DISP "EDIT OPTION (L,F,R,D,I,E)";
320 INPUT Z$
330 IF Z$="E" THEN 1580
340 IF Z$="F" THEN 450
350 IF Z$="R" THEN 630
360 IF Z$="D" THEN 920
370 IF Z$="I" THEN 1140
380 IF Z$="L" THEN 1330
390 DISP "COMMAND NOT VALID"
400 WAIT 1500
410 GOTO 310
420 REM
430 REM FIND OPTION.
440 REM
450 DISP "FIND: DAY, HOUR, MINUTE";
460 INPUT D1,H1,M1
470 IF D1 <= 0 THEN 310
480 FOR I1=1 TO L[3]
490 IF D[I1]#D1 OR T[I1,1]#H1 OR T[I1,2]#M1 THEN 550
500 WRITE (15,510)D1,H1*100+M1,I1
510 FORMAT "DATE",F3.0,1X,F5.2," KEY =",F4.0
520 PRINT
530 PRINT
540 GOTO 310
550 NEXT I1
560 PRINT "DATE NOT FOUND";D1,H1*100+M1
570 PRINT
580 PRINT
590 GOTO 310
600 REM
610 REM REPLACE OPTION.
620 REM
```

```
830 DISP "REPLACE KEY #";
840 INPUT I1
850 IF I1 <= 0 THEN 310
860 IF I1>L[3] THEN 820
870 FIXED 0
880 PRINT "OLD DAY: ";D[I1];" NEW=";
890 INPUT D[I1]
900 PRINT "OLD HOUR: ";T[I1,1];" NEW=";
910 INPUT T[I1,1]
920 PRINT "OLD MIN. ";T[I1,2];" NEW";
930 INPUT T[I1,2]
940 PRINT "OLD LAT. ";NL[I1,1];
950 FIXED 3
960 PRINT NL[I1,2];" NEW=";
970 INPUT NL[I1,1],NL[I1,2]
980 FIXED 0
990 PRINT "OLD LONG.";WL[I1,1];
1000 FIXED 3
1010 PRINT WL[I1,2];" NEW=";
1020 INPUT WL[I1,1],WL[I1,2]
1030 NL[I1,1]=-ABS(NL[I1,1])
1040 WL[I1,2]=-ABS(WL[I1,2])
1050 PRINT
1060 PRINT
1070 STANDARD
1080 GOTO 310
1090 REM
1100 REM DELETE OPTION.
1110 REM
1120 DISP "DELETE KEY #";
1130 INPUT I1
1140 IF I1 <= 0 THEN 310
1150 IF I1>L[3] THEN 920
1160 FOR I2=I1 TO L[3]-1
1170 D[I2]=D[I2+1]
1180 T[I2,1]=T[I2+1,1]
1190 T[I2,2]=T[I2+1,2]
1200 NL[I2,1]=NL[I2+1,1]
1210 NL[I2,2]=NL[I2+1,2]
1220 WL[I2,1]=WL[I2+1,1]
1230 WL[I2,2]=WL[I2+1,2]
1240 NEXT I2
1250 L[3]=L[3]-1
1260 FIXED 0
1270 PRINT "KEY #";I1;" DELETED"
1280 PRINT
1290 PRINT
1300 GOTO 310
1310 REM
1320 REM INSERT LINE.
1330 REM
1340 DISP "INSERT DATA BEFORE KEY #";
1350 INPUT I1
1360 IF I1 <= 0 THEN 310
1370 IF I1+1 >= L[1] THEN 1140
1380 FOR I2=L[3] TO I1 STEP -1
1390 D[I2+1]=D[I2]
1400 T[I2+1,1]=T[I2,1]
1410 T[I2+1,2]=T[I2,2]
1420 NL[I2+1,1]=NL[I2,1]
1430 NL[I2+1,2]=NL[I2,2]
1440 WL[I2+1,1]=WL[I2,1]
```

```
1250 W[I2+1,2]=W[I2,2]
1260 NEXT I2
1270 DISP "INSERT DAY, HR, MIN, LAT, LONG";
1280 INPUT D[I1],T[I1,1],T[I1,2],N[I1,1],N[I1,2],W[I1,1],W[I1,2]
1290 W[I1,1]=-ABS(W[I1,1])
1300 W[I1,2]=-ABS(W[I1,2])
1310 L[3]=L[3]+1
1320 GOTO 310
1330 REM
1340 REM LIST OPTION.
1350 REM
1360 DISP "LIST FROM-TO KEYS";
1370 INPUT I1,I2
1380 IF I1<0 THEN 310
1390 IF I2<I1 THEN 1360
1400 IF I1>0 THEN 1420
1410 I1=1
1420 IF I2<L[3] THEN 1440
1430 I2=L[3]
1440 PRINT
1450 PRINT "  KEY DAY HOUR  LATITUDE      LONGITUDE"
1460 PRINT
1470 FOR I3=I1 TO I2
1480 T1=T[I3,1]*100+T[I3,2]
1490 WRITE (15,1500)I3,D[I3],T1,N[I3,1],N[I3,2],W[I3,1],W[I3,2]
1500 FORMAT F4.0,1X,F3.0,1X,F5.0,1X,F3.0,F7.2,3X,F4.0,F7.2
1510 NEXT I3
1520 PRINT
1530 PRINT
1540 GOTO 310
1550 REM
1560 REM END OF EDIT.  STORE DATA  IF REQUESTED.
1570 REM
1580 DISP "SAVE DATA BEFORE LOGGING!!!!!"
1590 WAIT 5000
1600 DISP "ENTER FILE # FOR DATA SAVING";
1610 INPUT F1
1620 IF F1<0 THEN 1640
1630 STORE  DATA F1
1640 DISP "END OF EDIT.  BYE!!!"
1650 END
```

APPENDIX 7

OBSERVED MAGNETIC FIELD LOGGING AND ANOMALY CALCULATION

If the programs are not in memory, then see the detailed instructions on how to load programs from a program cassette (Appendix 3).

A bi-directional linear interpolation scheme is used to calculate the regional field value within the degree square of interest. The even five minute interpolation program must be run prior to this program.

To start the program press the 'f4' function key located on the upper left hand corner of the keyboard.

The program will display the following question:

ENTER FILE # FOR DATA RESTORE?

To load the navigation data from cassette, have the cassette in the cassette unit, and enter the file number for the correct data as:

4 (END OF LINE)

This will cause the data from file 4 to be read into memory. If the navigation data is already in memory then enter a -1 (minus one) as:

-1 (END OF LINE)

Next the program requests that you enter the START POINTER. This option allows you to start processing at other than the first time and position of the data. To start at the first data point enter a 1 as:

1 (END OF LINE)

To start at the 57-th point enter a 57 as:

57 (END OF LINE)

When the program needs new values for the regional field it will print the current latitude and longitude in the new degree square. Then it requests that you enter the degree bounds which surround this data point and the corresponding regional field values for the corners of this degree square. For example, the program might display the following line.

APPENDIX 7 (continued)

DATA AT 25.001 -70.537 (note: West is negative)

ENTER THE DEGREE BOUNDS

The degree bounds which surround this data point are: Top: 26°N; Bottom 25°N; Left: 71°W; and Right: 70°W. The numbers are entered in this order:

26, 25, 71, 70

Since north latitude and west longitude are assumed, no signs (+ or -) need to be included. The order is top, bottom, left, right.

The regional field values for each square for the time of the cruise has been calculated and tabulated. The table gives the following information:

DEGREE CROSSING	FIELD VALUE (gammas)
26 N, 71 W	48137
25 N, 71 W	47497
25 N, 70 W	47338
26 N, 70 W	47973

The computer will request the field values by typing:

ENTER 4 REG. FIELD VALUES

Enter the values in the order given above. That is, top left, bottom left, bottom right, top right:

48137, 47497, 47338, 47973 (END OF LINE)

For every data point within the degree square, the program will display the time as

ENTER VALUE FOR 1835?

Type in the measured value of the total magnetic field for this time. If there is no value, then enter a 0 (zero). For example, if the measured value is 47332 gammas, enter

47332 (END OF LINE)

APPENDIX 7 (continued)

If you do not want to enter any more values, then enter -1 (minus one). Any times skipped will have the anomaly value set to 30000. Any measured value larger than 60000 gammas or smaller than 30000 gammas will not be accepted and the program will ask for the value again.

When there is no more data or if you have given a -1 as the value for the measured field, the program will ask:

DO YOU WANT A LIST OF THE DATA?

If you do, then respond with a "YES". If you do not want a list, then answer "NO".

Finally, the program asks:

ENTER FILE # FOR DATA STORAGE:

To save the results on cassette, enter the file number of the cassette at which you want the data saved. For example, to save the data on file 7 enter

7 (END OF LINE)

Ordinarily the data is read back onto the same cassette file as it was read from. If you do not want to store the data on cassette, then enter a -1 (minus one) as

-1 (END OF LINE).

```
10 COM L$[80],Y$[3],D[30],T[30,2],N[30,2],W[30,2],P[200,2],A[200,3]
20 DIM Z$[3]
30 REM
40 REM   CALCULATE THE REGIONAL FIELD AND MAGNETIC ANOMALY
50 REM    USING THE HP9830 CALCULATOR
60 REM
70 REM USES THE DATA STORED IN COMMON VIA THE IPOS LYNCH DATA PROCESSING
80 REM    PACKAGE.  ALL DATA CONVENTIONS AND RESTRICTIONS MUST BE FOLLOWED.
90 REM    THE REGIONAL FIELD IS CALCULATED BY USING LINEAR INTERPOLATION
100 REM
110 REM    DATE: 11 SEPTEMBER 1976 - R. GROMAN
120 REM    HP 9830 CALCULATOR.
130 REM
140 REM    THE PROGRAM REQUIRES THE FOUR VALUES OF THE REGIONAL
150 REM    FIELD IN THE FOLLOWING ORDER:
160 REM    NORTHWEST, SOUTHWEST, SOUTHEAST, AND NORTHEAST CORNERS
170 REM    F1, F2, F3, F4 RESPECTIVELY, OF THE DEGREE SQUARE.
180 REM ALSO ENTER THE DEGREE BOUNDS TOP, BOTTOM, LEFT AN RIGHT FOR THESE
190 REM VALUES.  PROGRAM CHECKS IF DATA IS OUT OF THESE BOUNDS AND
200 REM WILL REQUEST NEW VALUES WHEN DATA FALLS OUTSIDE.
210 REM
220 REM THE CALCULATION REQUIRES THE SHIP'S LATITUDE AND
230 REM LONGITUDE AND THE CORRESPONDING TOTAL MEASURED MAGNETIC FIELD
240 REM IN GAMMAS.
250 REM
260 REM THE VALUES USED FOR THE LATITUDE AND LONGITUDE MUST ONLY BE
270 REM THE MINUTES PART OF THE POSITION.
280 REM THE LONGITUDE MUST BE NEGATIVE.
290 REM
300 REM
310 B1=-90
320 B2=90
330 B3=180
340 B4=-180
350 DISP "MAGNETIC ANOMALY CALCULATION"
360 WAIT 5000
370 DISP "ENTER FILE # FOR DATA RESTORE";
380 INPUT F1
390 IF F1<0 THEN 410
400 LOAD  DATA F1
410 DISP "ENTER START POINTER";
420 INPUT I1
430 IF I1=0 THEN 950
440 IF I1>0 THEN 470
450 I1=0
460 GOTO 950
470 I1=I1-1
480 GOTO 950
490 REM
500 REM ENTER NEW REGIONAL FIELD VALUES AND BOUNDS
510 REM
520 FIXED 3
530 PRINT "DATA AT";P[I1,1];P[I1,2]
540 STANDARD
550 WAIT 5000
560 PRINT
570 PRINT
580 PRINT "ENTER THE DEGREE BOUNDS";
590 INPUT B1,B2,B3,B4
600 IF B1=99 THEN 950
610 B3=-ABS(B3)
620 B4=-ABS(B4)
```

```
630 IF B2 >= B1 OR B4 <= B3 THEN 520
640 IF B1<20 OR B1>30 OR B2<20 OR B2>30 THEN 520
650 IF B3<-90 OR B3>-60 OR B4<-90 OR B4>-60 THEN 520
660 I1=I1-1
670 PRINT
680 PRINT
690 DISP "ENTER 4 REG. FIELD VALUES";
700 INPUT F1,F2,F3,F4
710 IF F1 <= 30000 THEN 690
720 IF F2 <= 30000 THEN 690
730 IF F3 <= 30000 THEN 690
740 IF F4 <= 30000 THEN 690
750 IF F2 <= F3 THEN 690
760 IF F1 <= F4 THEN 690
770 IF F4 <= F3 THEN 690
780 IF F1 <= F2 THEN 690
790 DISP "THANK YOU!!!"
800 WAIT 4000
810 PRINT
820 PRINT
830 PRINT
840 REM
850 REM CALCULATE REGIONAL FIELD DIFFERENCE BETWEEN EACH OF THE 4 CORNERS
860 REM
870 D1=F2-F1
880 D2=F3-F2
890 D3=F4-F3
900 D4=F1-F4
910 REM
920 REM GET THE POSITION (LATITUDE AND LONGITUDE MINUTES ONLY) NEEDED
930 REM WITHOUT SIGNS.  PROGRAM ASSUMES NORTH LATITUDE AND WEST LONGITUDE.
940 REM
950 I1=I1+1
960 IF I1>LL[4] THEN 1360
970 IF P[I1,1]>B1 OR P[I1,1]<B2 THEN 520
980 IF P[I1,2]>B4 OR P[I1,2]<B3 THEN 520
990 P1=(P[I1,1]-INT(P[I1,1]))*60
1000 P2=ABS(P[I1,2]-INT(P[I1,2]))
1010 P2=(1-P2)*60
1020 IF P1<0 THEN 950
1030 IF P2<0 THEN 950
1040 IF P1>60 THEN 950
1050 IF P2>60 THEN 950
1060 DISP "ENTER VALUE FOR";A[I1,1];
1070 INPUT M
1080 IF M#0 THEN 1110
1090 A[I1,2]=30000
1100 GOTO 950
1110 IF M<0 THEN 1360
1120 IF M <= 30000 THEN 1060
1130 IF M >= 60000 THEN 1060
1140 REM
1150 REM INTERPOLATE VALUES ALONG EACH SIDE OF THE DEGREE SQUARE
1160 REM
1170 L1=F2-(D1*(P1/60))
1180 L2=F3-(D2*(P2/60))
1190 L3=F4-(D3*((60-P1)/60))
1200 L4=F1-(D4*((60-P2)/60))
1210 REM
1220 REM INTERPOLATE BETWEEN THE PARALLEL SIDES.
1230 REM
1240 M=L3-((L3-L1)*(P2/60))
```

```
1250 V=L4-((L4-L2)*(60-P1)/60)
1260 REM
1270 REM AVERAGE THE HORIZONTAL AND VERTICAL COMPONENTS.
1280 REM
1290 R=(H+V)/2
1300 REM
1310 REM CALCULATE THE MAGNETIC ANOMALY.
1320 REM
1330 A1=R-B
1340 A[I1,2]=A1
1350 GOTO 1450
1360 FOR J1=L[4]+1 TO L[2]
1370 A[J1,2]=30000
1380 NEXT J1
1390 L[5]=I1-1
1400 DISP "DO YOU WANT A LIST OF THE DATA";
1410 INPUT Z$
1420 IF Z$#"YES" THEN 1550
1430 PRINT
1440 PRINT
1450 FIXED 0
1460 PRINT "    #    HOUR  LATITUDE     LONGITUDE  ANOMALY      START DAY =";D
1470 STANDARD
1480 PRINT
1490 FOR I1=1 TO L[5]
1500 WRITE (15,1510)I1,A[I1,1],P[I1,1],P[I1,2],A[I1,2]
1510 FORMAT 1X,F4.0,2X,F5.0,1X,F8.3,4X,F9.3,3X,F6.0
1520 NEXT I1
1530 PRINT
1540 PRINT
1550 PRINT
1560 DISP "ENTER FILE # FOR DATA STORAGE";
1570 INPUT F1
1580 IF F1<0 THEN 1600
1590 STORE  DATA F1
1600 PRINT
1610 DISP "ENTER FILE # FOR NEXT PROGRAM";
1620 INPUT F1
1630 PRINT
1640 PRINT
1650 PRINT
1660 PRINT
1670 PRINT
1680 IF F1<0 THEN 1700
1690 LOAD F1,10,10
1700 END
```

APPENDIX 8

MAGNETICS EDIT ROUTINE

The intent of the magnetics editing routine is to locate and correct erroneous geomagnetic data. Magnetic data will have already been logged and magnetic anomaly values calculated via program MAGNETIC LOGGING AND ANOMALY CALCULATION (Appendix 7). Three methods are used to detect bad values. These are 1) a smoothness criterian (excessive second drivative), 2) unreasonable value checking (lower limit), and 3) excessive deviation from median value of three points.

If the program is not in memory, than see the detailed instructions (Appendix 3) on how to load programs from the program cassette. Rewind the program cassette by pushing the 'REWIND' key on the upper right corner of the keyboard. Remove the cassette after it has been rewound. The printer must be on for this program.

The program will display the following:

```
MAGNETIC EDIT ROUTINE
ENTER FILE # FOR DATA RESTORE
```

Enter the file number of the magnetics data that you want placed into memory. The data cassette should be in the cassette reader. If the data is already in memory then enter -1. If you have indicated a file number greater than or equal to zero, the data will be read from the cassette. The program will print:

```
FILE ATTRIBUTES

L(3) = X    L(4) = Y      L(5) = Z
```

where X is the number of valid fixes in memory, Y is the maximum number of even five minute navigation (and data) points available and Z is the number of defined magnetic anomaly points.

The program will print

```
NEW VALUE FOR L(5) = ?
```

Enter the desired number of defined magnetic anomaly points. Entering a value of zero or less will leave L(5) unchanged. The purpose of this option is to permit deleting of erroneous (undefined) values of magnetic anomaly points at the end of the data array. The magnetics logging program can then be rerun starting with this new value of L(5). The program will print

NOW L(5) = W

to show that the value of L(5) is now equal to W.

Next the program executes the standard purge section where all anomaly values less than or equal to ten gammas are redefined to 30000, the null or 'no data' indication. Ten gammas is a reasonable cut-off value for this survey area. The program prints

n VALUES REDEFINED

to show how many points exceeded the cut-off value.

The program then executes the smoothness check section. The message

SMOOTHNESS CHECK SECTION

2-nd DERIVATIVE MAXIMUM = n % OF
MEDIAN ALLOWED = m

is printed and each magnetic anomaly point in turn is checked for smoothness (second derivative) and excessive deviation from median of surrounding points. The values of n and m are set to 35 gammas/kilometer and 10 percent, respectively. When a value does not pass the smoothness check the following is printed:

SMOOTHNESS ERROR

KEY = n PAST = X PRESENT = Y FUTURE = Z

TIME = T 2-nd = W

where n refers to the key number of the present value; X, Y, and Z refer to the past, present and future values of the magnetic anomaly data; T is the time of the present (or current value under consideration) and W is the calculated value of the second derivative. When a value does not pass the smoothness check it will then be checked for excessive deviation from median value. If this check is not passed then the following is printed:

BAD MEDIAN, VALUE = Y KEY = n

where Y is the anomaly value and n is its key number. Many values which only failed the smoothness check were found to be, in fact, valid values. However, most values which failed both tests were found to be incorrect on further examination. After all points in the array have been checked, the following message will be printed

p SMOOTHNESS ERRORS FOUND

where p is the number of points failing either or both tests.

The program will display

MAGNETIC KEY # TO REDEFINE?

Enter in the key number for the magnetic value you wish to redefine. Consult the results of the smoothness check section in order to select the key number. The program will print

OLD VALUE = Y NEW = ?

Enter in the new value you would like to assign. Y is the original value in gammas. The program will continue requesting a key number until a zero or negative value is supplied for the key number. The program then requests

START - END KEYS FOR LIST?

Enter the first and last key number of records you would like to list out on the printer. These records are printed under the following heading:

#, HOUR, LATITUDE, LONGITUDE, and ANOMALY

The start day (START DAY =) is printed at the start of the list for reference. Enter negative values for no list.

Finally, the program gives you the option of storing the modified data back onto cassette. The program will display:

ENTER FILE # FOR DATA STORAGE?

Enter a negative number if you do not want to write the data back to cassette. The program ends with

END OF MAGNETICS EDIT.

```
10 COM L[10],Y$[3],D1[30],T1[30,2],NS[30,2],WS[30,2],P$[200,2],A1[200,3]
20 DIM Z$[3]
30 REM
40 REM   EDIT THE MAGNETICS DATA ARRAY.  ALLOWS FOR INDIVIDUAL EDIT
50 REM   AS WELL AS A STANDARD PURGE OF BAD VALUES.
60 REM
70 REM 1 SEPTEMBER 1976  -  R. GROMAN
80 REM
90 REM   USES THE DATA STORED IN COMMON VIA THE IPOD LYNCH DATA PROCESSING
100 REM   PACKAGE.  ALL DATA CONVENTIONS AND RESTRICTIONS MUST BE FOLLOWED.
110 REM   THE REGIONAL FIELD IS CALCULATED BY USING LINEAR INTERPOLATION
120 REM
130 REM
140 DISP "MAGNETICS EDIT ROUTINE"
150 WAIT 3000
160 DISP "ENTER FILE # FOR DATA RESTORE";
170 INPUT F1
180 IF F1<0 THEN 200
190 LOAD  DATA F1
200 PRINT "FILE ATTRIBUTES"
210 PRINT "L(3)=";L[3];"L(4)=";L[4];"L(5)=";L[5]
220 PRINT
230 PRINT
240 PRINT
250 DISP "NEW VALUE FOR L(5) = ";
260 INPUT L1
270 IF L1<= 0 THEN 200
280 IF L1>L[4] THEN 250
290 L[5]=L1
300 PRINT
310 PRINT "NOW L(5) = ";L[5]
320 PRINT
330 DISP "STANDARD PURGE SECTION"
340 J1=0
350 FOR I1=1 TO L[5]
360 IF ABS(A1[I1,2])>10 THEN 390
370 A1[I1,2]=30000
380 J1=J1+1
390 NEXT I1
400 FOR I1=L[5]+1 TO L[4]
410 A1[I1,2]=30000
420 NEXT I1
430 PRINT J1;" VALUES REDEFINED"
440 PRINT
450 PRINT
460 DISP "SMOOTHNESS CHECK SECTION"
470 REM ASSUMES CONSTANT SPEED AND EVENLY SPACED DATA.
480 REM
490 REM C1 HAS UNITS OF GAMMAS/KM.  (SECOND DERIVATIVE MAXIMUM)
500 REM
510 REM USES ROBUST MODELING TECHNIQUE (MEDIAN) TO FIND OFFENDING VALUE
520 REM D1 IS THE MAXIMUM PERCENT OF MEDIAN PERMISSABLE
530 REM
540 J1=0
550 C1=25
560 D1=0.1
570 PRINT "2ND DERIVATIVE MAXIMUM=";C1;"% OF MEDIAN ALLOWED=";D1
580 FOR I1=2 TO L[5]-1
590 G1=ABS(A1[I1-1,2]-2*A1[I1,2]+A1[I1+1,2])
600 IF ABS(G1) <= C1 THEN 750
610 IF A1[I1-1,2] >= 30000 OR A1[I1,2] >= 30000 OR A1[I1+1,2] >= 30000 THEN 750
620 PRINT
```

```
630 PRINT "    SMOOTHNESS ERROR"
640 WRITE (15,650)I1,A(I1-1,2),A(I1,2),A(I1+1,2)
650 FORMAT "KEY=",F4.0," PAST=",F6.0," PRESENT=",F6.0," FUTURE=",F6.0
660 WRITE (15,670)A(I1,1),G1
670 FORMAT 2X,"TIME= ",F5.0,4X,"2-ND = ",F6.1
680 M1=FNM(1)
690 FOR I2=I1-1 TO I1+1
700 IF ABS(A(I2,2))<ABS(M1+N1*D1) AND ABS(A(I1,2)) >ABS(M1-M1+D1) THEN 730
710 WRITE (15,720)A(I2,2),I2
720 FORMAT 30X,"BAD MEDIAN, VALUE = ",F6.0,3X,"KEY=",F4.0
730 NEXT I2
740 J1=J+1
750 NEXT I1
760 PRINT
770 PRINT J1;"SMOOTHNESS ERRORS FOUND"
780 PRINT
790 PRINT
800 PRINT
810 PRINT
820 PRINT
830 REM
840 REM EDITING SPECIFIC MAGNETICS VALES.
850 REM
860 DISP "MAGNETICS KEY # TO REDEFINE";
870 INPUT I1
880 IF I1 <= 0 THEN 980
890 IF I1=0 THEN 860
900 PRINT "OLD VALUE=";A(I1,2);" NEW = ";
910 INPUT A(I1,2)
920 IF A(I1,2)>0 THEN 860
930 A(I1,2)=30000
940 GOTO 860
950 REM
960 REM LIST OUT VALES
970 REM
980 DISP "START - END KEYS FOR LIST";
990 INPUT I1,I2
1000 IF I1>0 THEN 1030
1010 IF I1<0 THEN 1150
1020 I1=1
1030 IF I1>I2 THEN 980
1040 IF I2<L[5] THEN 1060
1050 I2=L[5]
1060 PRINT
1070 FIXED 0
1080 PRINT "    #    HOUR  LATITUDE     LONGITUDE  ANOMALY      START DAY =";D[1
1090 STANDARD
1100 PRINT
1110 FOR J1=I1 TO I2
1120 WRITE (15,1130)J1,A(J1,1),P(J1,1),P(J1,2),A(J1,2)
1130 FORMAT 1X,F4.0,2X,F5.0,1X,F8.3,4X,F9.3,3X,F6.0
1140 NEXT J1
1150 PRINT
1160 PRINT
1170 PRINT
1180 DISP "ENTER FILE # FOR DATA STORAGE";
1190 INPUT F1
1200 IF F1<0 THEN 1220
1210 STORE  DATA F1
1220 PRINT
1230 PRINT
1240 PRINT
```

```
1250 DISP "END OF MAGNETICS EDIT"
1260 END
1270 DEF FNM(I)
1280 REM FND MEDIAN VALUE OF THREE VALUES
1290 REM ORDER NUMBERS
1300 Z[1]=A[I-1,2]
1310 Z[2]=A[I,2]
1320 Z[3]=A[I+1,2]
1330 FOR Z1=1 TO 3
1340 FOR Z2=1 TO 3
1350 IF Z[Z1]<Z[Z2] THEN 1390
1360 Z3=Z[Z1]
1370 Z[Z1]=Z[Z2]
1380 Z[Z2]=Z3
1390 NEXT Z2
1400 NEXT Z1
1410 RETURN Z[2]
1420 END
```

APPENDIX 9

NAVIGATION PLOTTING PROGRAM

This program plots navigational fixes on an operator specified Mercator grid and annotates the time at right angles to the track line.

To load the program, insert the program cassette. and load the file by typing LOAD < file # >. Start the program by typing "RUN". "REWIND" the program cassette and insert the data cassette.

The operator is queried five times as follows:

1. Mercator grid parameters. Enter the longitude scale in inches per degree, and the number of minutes between grid lines desired. Thirty minutes would draw two lines for each degree.

2. File number of data to be plotted (enter -1, if data are already in core); option to list the positions plotted on the printer (1 to list, -1 not to); minimum spacing between annotations in inches (prevents successive number of annotations from overprinting). The minimum separation should be 0.1 inch, the size of the numbers. On a smaller scale chart, a larger value is suitable. After this entry, there will be a pause while the data file is loaded into core.

3. Bounds of the plot in degrees and minutes. Enter in the following order - top, bottom, left, right.

4. The terminal will display "SET PLOTTER" and then give the dimensions to set the plotter in inches. These dimensions include a one inch border on the left, and a half inch border on the top, bottom and right on the 10"x15" plotter. After setting the plotter pen to the specified dimensions using the LOWER LEFT and UPPER RIGHT controls, resume the program by typing "CONT" and "EXECUTE".

APPENDIX 9 (continued)

5. The final query is a label for the left-hand margin of the plot. Make the entry slowly because the plotter annotates each letter as you type it. Wait for "ENTER LABEL AND RUN TIME" to reappear before typing the next letter or space. When finished with the last letter, type the "STOP" key and the program will resume. When circumstances might involve making repeated plots of the same fixes, such as in editing the navigation, it is useful to include the run time and date in the label, so to facilitate identification of the chronology of the plots.

The grid is drawn and the bounds labelled. The positions are marked with a dot and the time annotated. If the list option in entry 2 is taken, a list of all the fix positions and times falling within the specified grid will be printed. At the conclusion of the plotting, the printer will log the number of points and display "END OF DATA" on the calculator.

To plot additional files on the same grid, type "CONT" and "EXECUTE". The terminal will ask for the number of the next file on the data cassette (which could be on another cassette). Be sure to "REWIND" each cassette before removing it from the reader, to reduce the chance of tape damage.

NAVIGATION CHARTING SAMPLE 16 INCHES/DEGREE
27.33
-27.00
-67.50
-67.00
1750
745
740
735
730
725
720
715
710
705
700
655
650
645
640
635
1630
1635
1640
1645
1650
1655
1700
1705
1710
1715
1720
1725
1730
1735
1740
1745
1750
1415
1420
1425
1430
1435
1440
1445
1450
1455
1500
1505
1510
1515
1520
1525
1530
1535
1540
1545
1550
1600
1610
1615
1620
1625

```
10 COM L$[10],Y$[3],D[30],T[30,2],N$[30,2],W$[30,2],P$[200,2],A[200,3]
20 REM PLOT DATA ON MERCATOR CHART
30 DISP "NAVIGATION PLOTTING PROGRAM"
40 WAIT 4000
50 DISP "ENTER SCALE, MIN PER GRID LINE";
60 REM INCHES PER DEGREE LONGITUDE
70 REM 60 MIN GIVES ONE GRID LINE PER DEGREE
80 INPUT F0,F4
90 DISP "FILE # FOR DATA, LIST OPT, MIN SPACING";
100 REM NEGATIVE ENTRY IF DATA ALREADY IN CORE
110 REM POSITIVE ENTRY FOR LIST OF PLOTTED POINTS
120 REM MINIMUM SPACING 0.1
130 INPUT F1,F2,F3
140 F3=F3/F0
150 IF F1<0 THEN 170
160 LOAD  DATA F1
170 DISP "E BOUNDS OF PLOT IN DEG MIN"
180 WAIT 1500
190 DISP "TOP BOTTOM LEFT RIGHT";
200 REM PROGRAM ASSUMES NORTHWEST QUADRASPHERE
210 REM SET PAPER AND LIMITS TO CORRECT SCALE
220 INPUT L1,M1,L2,M2,L3,M3,L4,M4
230 REM MAKE SURE SIGN OF MIN AND DEG AGREE
240 IF ABS(L1)<1 THEN 260
250 M1=ABS(M1)*SGN(L1)
260 IF ABS(L2)<1 THEN 280
270 M2=ABS(M2)*SGN(L2)
280 IF ABS(L3)<1 THEN 300
290 M3=ABS(M3)*SGN(L3)
300 IF ABS(L4)<1 THEN 320
310 M4=ABS(M4)*SGN(L4)
320 L5=L1+M1/60
330 L6=L2+M2/60
340 L7=L3+M3/60
350 L8=L4+M4/60
360 L9=L6
370 L0=L5
380 L5=FNM(L5)/60
390 L6=FNM(L6)/60
400 D0=(L8-L7)*F0
410 D1=(L5-L6)*F0
420 DISP "SET PLOTTER"
430 WAIT 2000
440 FIXED 2
450 D0=D0+1.5
460 D1=D1+1
470 D9=10/D1
480 REM MAKE ONE INCH LEFT MARGIN, HALF INCH TOP BOTTOM RIGHT
490 K7=L7-1/F0
500 K8=L8+1/(2*F0)
510 K6=L6-1/(2*F0)
520 K5=L5+1/(2*F0)
530 D5=(K5-K6)/(K8-K7)
540 DISP "X=";D0;"Y=";D1;"INCHES"
550 STOP
560 REM PLOT GRID SCALE
570 SCALE K7,K8,K6,K5
580 REM LABEL ON LEFT HAND MARGIN
590 LABEL (*,D9,1.7,PI/2,D5)
600 PLOT K7+0.2/F0,K6+0.2/F0,1
610 DISP "ENTER LABEL AND RUN TIME"
```

```
620 LETTER
630 F4=60/F4
640 M7=INT(ABS((L8-L7)*F4)+0.5)-1
650 M8=INT(ABS((L6-L5)*F4)+0.5)-1
660 REM DRAW OUTSIDE GRID
670 PLOT L7,L6,1
680 PLOT L8,L6,2
690 PLOT L8,L5
700 PLOT L7,L5
710 PLOT L7,L6
720 REM ANNOTATE BOUNDS
730 PLOT L7+0.1/F0,L6+0.25/F0,1
740 LABEL (*),D9,1.7,0,D5,L9
750 PLOT L7+0.1/F0,L6+0.1/F0,1
760 LABEL (*)L7
770 PLOT L8-0.6/F0,L6+0.1/F0,1
780 LABEL (*)L8
790 PLOT L7+0.1/F0,L5-0.2/F0,1
800 LABEL (*)L0
810 PLOT L7,L6,1
820 REM DRAW INTERMEDIATE TEN MINUTE LONG LINES FROM LEFT TO RIGHT
830 FOR I=1 TO M7
840 D0=L7+I/F4
850 PLOT D0,L6,1
860 PLOT D0,L5,2
870 NEXT I
880 PLOT L7,L6,1
890 REM DRAW INTERMEDIATE TEN MINUTE LAT LINES FROM BOTTOM TO TOP
900 FOR I=1 TO M8
910 D1=L9+I/F4
920 D1=FNM(D1)/60
930 PLOT L7,D1,1
940 PLOT L8,D1,2
950 NEXT I
960 PLOT L7,L6,1
970 REM END OF GRID PLOT
980 D2=0
990 D4=0
1000 I2=0
1010 REM READ DATA FILE, PLOT VALUES IN BOUNDS
1020 FOR I=1 TO L[4]
1030 D1=FNM(P[I,1])/60
1040 REM CHECK IF DATA IN BOUNDS
1050 IF P[I,1]<L9 THEN 1290
1060 IF P[I,1]>L0 THEN 1290
1070 IF P[I,2]<L7 THEN 1290
1080 IF P[I,2]>L8 THEN 1290
1090 PLOT P[I,2],D1,-2
1100 PLOT P[I,2],D1,1
1110 REM SKIP ANNOTATION IF POINT TOO CLOSE TO LAST
1120 D7=P[I,2]-D3
1130 D6=D1-D4
1140 IF SQR(D7*D7+D6*D6)<F3 THEN 1310
1150 REM ANNOTATE POINT
1160 FIXED 0
1170 REM DETERMINE ANGLE SO TO PLOT DATA PERPENDICULAR TO TRACK
1180 D0=ATN(D6/D7)-PI/2
1190 IF D6/D7>0 THEN 1210
1200 D0=D0+PI
1210 LABEL (*),D9,1.7,D0,D5)
1220 PLOT 1,-0.3
1230 LABEL (*)A[I,1]
```

```
1240 J2=J2+1
1250 FIXED 2
1260 IF I2 <= 0 THEN 1290
1270 WRITE (15,1280)A[I,1],P[I,1],P[I,2]
1280 FORMAT F5.0,2F8.2
1290 D3=P[I,2]
1300 D4=D1
1310 NEXT I
1320 FIXED 0
1330 PRINT 'POINTS PLOTTED=";J2;"FILE=";F1
1340 STANDARD
1350 DISP "END OF DATA"
1360 STOP
1370 REM TO PLOT ANOTHER FILE ON SAME GRID, PUSH "CONT"
1380 DISP "ENTER NEXT FILE #";
1390 INPUT F1
1400 LOAD  DATA F1
1410 GOTO 1000
1420 REM
1430 DEF FNM(X)
1440 REM CALCULATES MERIDIONAL PARTS FROM THE EQUATOR TO THE GIVEN LATITUDE
1450 REM IN DEGREES AND FRACTIONS OF DEGREE.
1460 REM REFERENCE: BOWDITCH, 1962.
1470 REM
1480 M9=(45+(X/2))/57.29577951
1490 M9=7915.704468*LGT(TAN(M9))
1500 M9=M9-23.268932*SIN(X/57.29577951)
1510 M9=M9-0.0525*((SIN(X/57.29577951))↑3)
1520 M9=M9-0.000213*((SIN(X/57.29577951))↑5)
1530 RETURN M9
1540 END
```

APPENDIX 10

PROGRAM FOR PLOTTING DATA ALONG SHIP'S TRACK

This program plots data along the ship's track using the track line as a datum. The perpendicular displacement from the track is proportional to an operator specified scale. The track is plotted on a Mercator grid as a series of dots and the data as a continuous trace. The trace is broken at course changes of more than thirty degrees and if there is a gap in the data. The track line can be assigned an arbitrary value so that the fluctuations in the plotted parameter can be displayed at a larger scale if desired. Positive values are plotted on the "top" side of the track, minus values below.

To load the program, insert the program cassette and load the file by typing LOAD < file # >. Start the program by typing "RUN". "REWIND" the program cassette and insert the data cassette.

The operator is queried six times as follows:

1. Mercator grid parameters. Enter the longitude scale in inches per degree, and the number of minutes between grid lines desired. Fifteen minutes would draw four lines for each degree.

2. File number of data cassette to be plotted (enter -1, if data is already in core); option to list the time, position and data plotted (enter "1" for listing, "-1" not to). After this entry there will be a pause while the data are loaded from the specified cassette file.

3. Two parameters controlling the deflection and placement of the data track in respect to the track line are requested. First the scale in scientific units per inch displacement from the track; second a constant bias value to be subtracted from all data values. For plotting the geomagnetic field anomaly, 500, 0 are typically entries. For bathymetry -200, 2000 might be entered, where 2000 is the average depth of the water. The minus 200 is used to invert the sounding profile so that shallower values plotted above deeper values, since soundings are all negative in respect to the sea surface.

APPENDIX 10(continued)

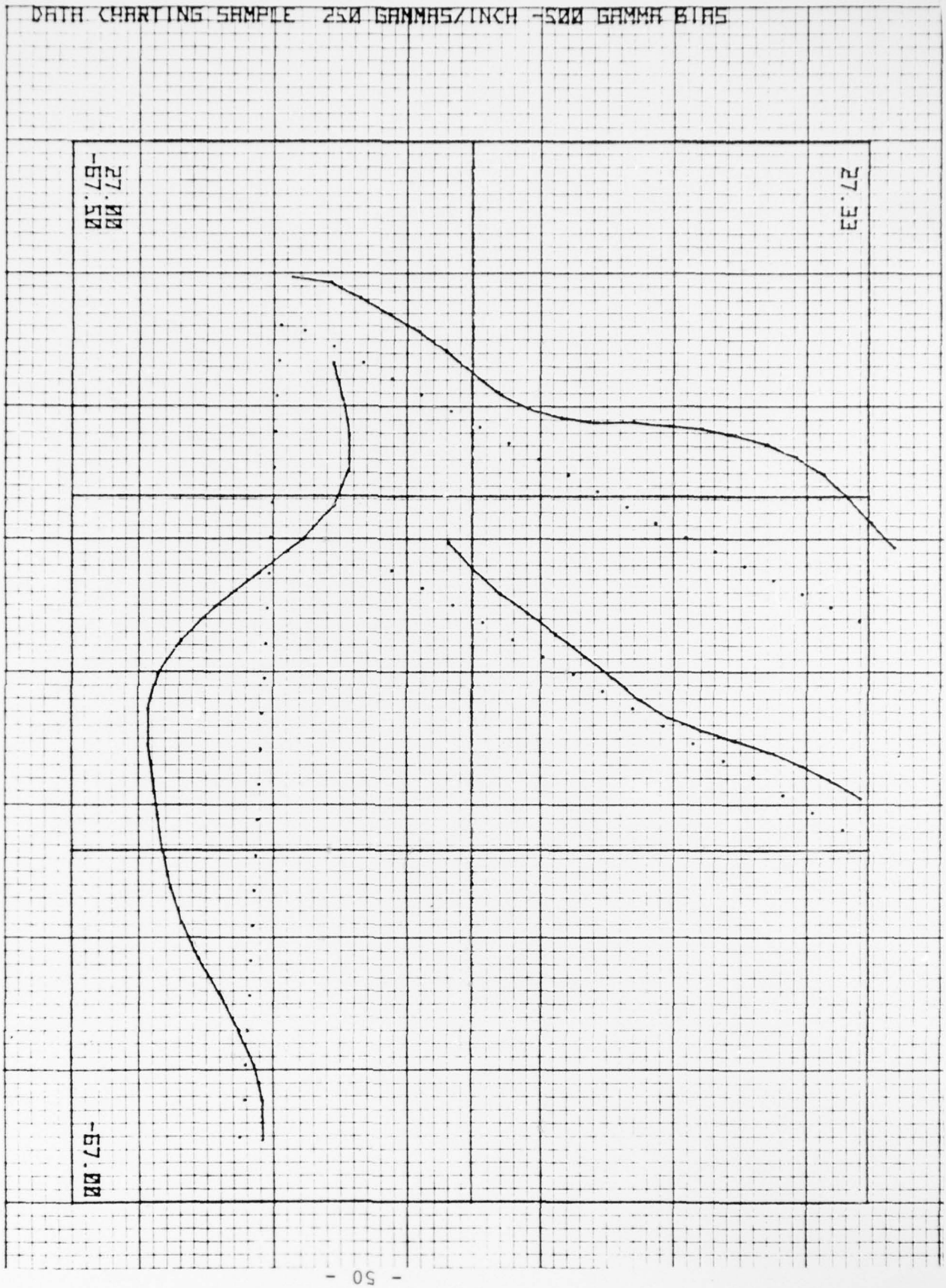
4. Bounds of the plot in degrees and minutes. Enter in the following order - top, bottom, left, right. Latitude north is positive, and longitude west is negative in the program. If the minus sign is not entered the plot will be reversed right for left.

5. The calculator will display "SET PLOTTER" and then give the dimensions to set the plotter in inches. These dimensions include a one inch border on the left, and a half inch border on the top, right and bottom. After setting the plotter pen to the specified dimensions using the LOWER LEFT and UPPER RIGHT controls, resume the program by typing "CONT" and "EXECUTE".

6. The final query is a label for the left-hand margin of the plot. Make the entry slowly because the plotter annotates each letter as you type it. Wait for "ENTER LABEL AND RUN TIME" to reappear before typing the next letter or space. The label should include the scale and bias, as well as the file description and date of run. The entire left margin can be used. When finished type the "STOP" key and the plotting will begin.

The grid is drawn first and the bounds labelled. The ship's track is indicated by a series of dots as the program scans the data file. The data points are then plotted by a smooth trace as the program scans the data file a second time. If the list option in entry 2 is opted, a list of all the times, positions and data values within the grid is given on the printer. At the end of the data file the program will log the number of data points plotted.

To plot additional files on the same grid, type "CONT" and "EXECUTE". The terminal will ask for the number of the next file on the data cassette (which could be on another cassette). Be sure to "REWIND" each cassette before removing it from the reader, to reduce the chance of tape damage.


DATA CHARTING SAMPLE 250 GAMMAS/INCH -500 GAMMA BIAS
-57.00
-57.50
27.33

```
10 DIM L$[10],Y$[3],D$[30],TI[30,2],NS[30,2],NS[30,2],PS[200,2],A[200,3]
20 REM PLOT DATA ON MERCATOR CHART
30 DISP "DATA CHARTING PROGRAM"
40 WAIT 4000
50 DISP "ENTER SCALE, MIN PER GRID LINE";
60 REM INCHES PER DEGREE LONGITUDE
70 REM 60 MIN GIVES ONE GRID LINE PER DEGREE
80 INPUT F0,F4
90 DISP "FILE # FOR DATA, LIST OPT";
100 INPUT F1,F2
110 DISP "VAR SCALE (UNITS/INCH),BIAS";
120 REM SCIENTIFIC UNITS PER INCH DISPLACEMENT FROM TRACK
130 REM BIAS TO BE SUBTRACTED FROM DATA
140 INPUT A1,A4
150 IF F1<0 THEN 170
160 LOAD  DATA F1
170 DISP "E BOUNDS OF PLOT IN DEG MIN"
180 WAIT 1500
190 DISP "TOP BOTTOM LEFT RIGHT";
200 REM PROGRAM ASSUMES NORTHWEST QUADRASPHERE
210 INPUT L1,M1,L2,M2,L3,M3,L4,M4
220 REM MAKE SURE SIGN OF MIN AND DEG AGREE
230 IF ABS(L1)<1 THEN 250
240 M1=ABS(M1)*SGN(L1)
250 IF ABS(L2)<1 THEN 270
260 M2=ABS(M2)*SGN(L2)
270 IF ABS(L3)<1 THEN 290
280 M3=ABS(M3)*SGN(L3)
290 IF ABS(L4)<1 THEN 310
300 M4=ABS(M4)*SGN(L4)
310 L5=L1+M1/60
320 L6=L2+M2/60
330 L7=L3+M3/60
340 L8=L4+M4/60
350 L9=L6
360 L0=L5
370 L5=FNM(L5)/60
380 L6=FNM(L6)/60
390 D0=(L8-L7)*F0
400 D1=(L5-L6)*F0
410 D0=D0+1.5
420 D1=D1+1
430 D9=10/D1
440 REM MAKE ONE INCH LEFT MARGIN, HALF INCH TOP BOTTOM RIGHT
450 K7=L7-1/F0
460 K8=L8+1/(2*F0)
470 K6=L6-1/(2*F0)
480 K5=L5+1/(2*F0)
490 D5=(K5-K6)/(K8-K7)
500 DISP "SET PLOTTER"
510 WAIT 2000
520 FIXED 2
530 DISP "X=";D0;"Y=";D1;"INCHES"
540 REM MOUNT PAPER AND SET LIMITS
550 STOP
560 REM PLOT GRID SCALE
570 SCALE K7,K9,K6,K5
580 REM LABEL ON LEFT HAND MARGIN
590 LABEL (*,D9,1.7,PI/2,D5)
600 PLOT K7+0.1/F0,K6+0.2/F0,1
610 DISP "ENTER LABEL AND RUN TIME"
```

```
620 LETTER
630 F4=60/F4
640 M7=INT(ABS((L8-L7)*F4)+0.5)-1
650 M8=INT(ABS((L6-L5)*F4)+0.5)-1
660 REM DRAW OUTSIDE GRID
670 PLOT L7,L6,1
680 PLOT L8,L6,2
690 PLOT L8,L5
700 PLOT L7,L5
710 PLOT L7,L6
720 REM ANNOTATE BOUNDS
730 PLOT L7+0.1/F0,L6+0.25/F0,1
740 LABEL (*,D9,1.7,0,D5)L9
750 PLOT L7+0.1/F0,L6+0.1/F0,1
760 LABEL (*)L7
770 PLOT L8-0.6/F0,L6+0.1/F0,1
780 LABEL (*)L8
790 PLOT L7+0.1/F0,L5-0.2/F0,1
800 LABEL (*)L0
810 PLOT L7,L6,1
820 REM DRAW INTERMEDIATE LONG LINES FROM LEFT TO RIGHT
830 FOR I=1 TO M7
840 D0=L7+I/F4
850 PLOT D0,L6,1
860 PLOT D0,L5,2
870 NEXT I
880 PLOT L7,L6,1
890 REM DRAW INTERMEDIATE LAT LINES FROM BOTTOM TO TOP
900 FOR I=1 TO M8
910 D1=L9+I/F4
920 D1=FNM(D1)/60
930 PLOT L7,D1,1
940 PLOT L8,D1,2
950 NEXT I
960 PEN
970 REM END OF GRID PLOT
980 D3=0
990 D4=0
1000 A2=0
1010 REM PLOT DATA FILE VALUES IN BOUNDS
1020 REM FIRST PASS DOTTED TRACK, SECOND PASS DATA
1030 F9=1
1040 REM Z1 PARAMETER HANDLES TRACK RUNNING OFF AND BACK ON GRID
1050 Z1=0
1060 FOR I=1 TO L[4]
1070 A1=FNM(P[I,1])/60
1080 REM CHECK IF DATA IN BOUNDS
1090 IF P[I,1]<L9 THEN 1460
1100 IF P[I,1]>L0 THEN 1460
1110 IF P[I,2]<L7 THEN 1460
1120 IF P[I,2]>L8 THEN 1460
1130 REM CHECK FOR BAD DATA VALUES
1140 IF P[I,2]>10000 OR P[I,2]<-10000 AND F9=2 THEN 1470
1150 IF F9=2 THEN 1200
1160 PLOT P[I,2],D1,-2
1170 PLOT P[I,2],D1,1
1180 IF F9=1 THEN 1520
1190 REM SKIP FIRST DATA POINT
1200 IF I=1 THEN 1490
1210 A=P[I,2]-D3
1220 B=D1-D4
1230 REM DETERMINE ANGLE SO TO PLOT DATA PERPENDICULAR TO TRACK
```

```
1240 D0=ATN(ABS(D6/D7))-PI/2
1250 IF D0<0 THEN 1270
1260 D0=D0+PI/2
1270 D0=ABS(D0)
1280 A0=(A[I,2]-A4)/A1
1290 D3=A0*COS(D0)/F0
1300 IF D6/D7<0 THEN 1320
1310 D3=-D3
1320 D3=D3+P[I,2]
1330 D4=A0*SIN(D0)/F0+D1
1340 REM PEN UP TO FIRST POINT
1350 IF I=2 THEN 1370
1360 IF ABS(D8-D0)<PI/6 AND Z1=0 THEN 1380
1370 PLOT D3,D4,1
1380 PLOT D3,D4,2
1390 Z1=0
1400 J2=J2+1
1410 IF F2 <= 0 THEN 1490
1420 FIXED 2
1430 WRITE (15,1440)A[I,1],P[I,1],P[I,2]
1440 FORMAT F5.0,2F8.2
1450 GOTO 1490
1460 IF F9=1 THEN 1490
1470 PEN
1480 Z1=1
1490 D3=P[I,2]
1500 D4=D1
1510 D8=D0
1520 NEXT I
1530 IF F9=2 THEN 1570
1540 Z1=1
1550 F9=2
1560 GOTO 1060
1570 PEN
1580 FIXED 0
1590 PRINT "POINTS PLOTTED=";J2
1600 STANDARD
1610 DISP "END OF FILE";F1
1620 STOP
1630 REM TO PLOT ANOTHER FILE ON SAME GRID, TYPE "CONT", "EXEC"
1640 DISP "ENTER NEXT FILE #";
1650 INPUT F1
1660 LOAD  DATA F1
1670 GOTO 1000
1680 REM
1690 DEF FNM(X)
1700 M9=(45+(X/2))/57.29577951
1710 M9=7915.704468*LGT(TAN(M9))
1720 M9=M9-29.263932*SIN(X/57.29577951)
1730 M9=M9-0.0525*((SIN(X/57.29577951))↑3)
1740 M9=M9-0.000218*((SIN(X/57.29577951))↑5)
1750 RETURN M9
1760 END
```

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